Milford Ice & Coal, circa 1893
100 feet east of State Route 14 on the
Mispillion River
Milford
Sussex County
Delaware

HAER DE-4

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PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
National Park Service
Department of the Interior
Washington, D. C. 20240

HISTORIC AMERICAN ENGINEERING RECORD

Milford Ice & Coal

HAER DE-4

Location:	Milford, Delaware
Date of Construction:	c. 1893; c. 1925
Present Owner	Sudler Lofland
Present Use:	In 1976, Lofland scrapped the ice-making machinery. Structure was scheduled for re-use or demolition.
Significance:	Milford Ice and Coal, founded by George H. Draper in the early 1890's, was one of the first mechanical ice plants in Delaware. The firm changed hands several times before ending ice production in 1975. Although the physical plant was often altered, the basic operation changed little since construction.
Historian:	Christopher Derganc, 1976.

I. Development of the Manufactured Ice Industry in the United States

Experimental efforts to produce refrigeration mechanically date from the mid-18th century when William Cullen, a Scottish physician, constructed an apparatus capable of freezing water. [1] Many other ice-making devices soon followed, including those of Americans Oliver Evans and Jacob Perkins, but none received the financial support necessary for commercial exploitation. [2] In the United States, bountiful New England ice harvests, coupled with the entrepreneurial activities of ice-traders like Frederik Tudor, precluded all but experimental endeavors until the Civil War. [3] The technology requisite for producing artificial ice existed, but the stimulus for further development did not.

However, the outbreak of war in 1861, and the subsequent suspension of ice shipments to Confederate ports, stimulated southern interest in mechanical refrigeration. This interest continued, despite resumption of ice shipments to the South in the late 1860's. In fact, the decade following the conclusion of the Civil War witnessed

> "more fruitful advancement in the art and science of ice-making . . . than had occurred in the 113 years since William Cullen . . . triggered the investigation on how to produce man-made cold." [4]

This advancement was restricted however, to the region south of the Potomac, where "a cheap, dependable supply of ice was needed." [5] In 1869, there were 4 plants producing ice for sale in the United States, all located in the South. This number increased to 222 in 1889, 165 of which were in southern states. [6] Manufactured ice attained such a dominant position, that by 1890, natural ice was no longer a significant item of trade in the South. [7]

While progress was swift in the South, it was slow in the North, where natural ice remained relatively abundant and cheap. However, the mild winters of 1888-1889 and 1889-1890 seriously diminished the natural ice harvest and set off a rapid extension of ice manufacturing technology to all but the New England states:

> "The serious shortages in the following summers, a striking demonstration of the inadequacy of natural ice, gave rise to an unprecedented demand for refrigerating machinery, not only for ice making, but for all industries which required low temperatures. This led to a new era in mechanical refrigeration" [8]

Natural ice remained a viable enterprise for some time, due to the tremendous increase in the nationwide consumption of ice, but by the 1920's the industry had "ceased to be big business." [9] Ice plant construction increased steadily. By 1931, there were over 4,000 commercial plants in the United States. [10] During the 1920's and 1930's, methods used to produce artifical ice were applied on a smaller scale for use in direct-cooling equipment. The development of small commercial and domestic refrigerators and freezers initiated the downfall of the U.S. ice industry. By 1967, there were only 947 plants still producing ice for sale in this country. [11]

The first mechanical ice plant in the state of Delaware began operation in the 1880's; by 1899, seven were in business. [12] Development was most extensive in the two southern counties of Kent and Sussex. These counties lacked a large, urban population center like Wilmington, whose location on a major trade route allowed for the importation of natural ice at relatively low cost. (The neighboring urban centers of Philadelphia, Baltimore and Washington all received sizeable natural ice shipments as late as 1908.) [13] Furthermore, due to the growing use of ice to refrigerate produce and meat shipments in the late 19th and early 20th centuries, the agricultural economies of Kent and Sussex required a dependable and reasonably priced source of ice. Manufactured ice provided a viable solution. [14]

By 1914, there were eighteen ice plants in the state, with an average yearly output of $16,315.00 each. [15] This very small production was indicative of the decentralized nature of the industry generally. It was cheaper to build a plant in an area of new demand than to ship ice over large distances. Markets were generally restricted to a maximum of twenty to twenty-five miles. [16]

In 1960, there were eleven plants still manufacturing ice in Delaware, ten in the southern counties. [17] The market for these plants was small, consisting primarily of the icing of refrigerated produce trucks and supplying domestic needs beyond the scope of home refrigerating equipment. [18]

II. General History of Milford Ice and Coal [19]

One of the first mechanical ice plants in Delaware was that established by George H. Draper and Associates in Milford, Sussex County, in the early 1890's (see insurance map #1). The plant was of the ammonia compression type and had a daily capacity of ten tons. Two large structures located to the rear of the main building served as storage for manufactured ice. All machinery was powered by a forty horsepower steam engine. A siding track of the Philadelphia, Baltimore and Washington Railroad facilitated the icing of refrigerator cars carrying southern Delaware produce. [20] Sometime later, Draper added a retail coal line to his business, probably in an attempt to fill in the seasonal fluctuations of the ice business and to ease fuel costs for the coal-fired boiler.

Around 1910, Charles E. Verney purchased the plant, which had by then acquired a seventy-five horsepower steam engine to replace the older one (see insurance map #2).

A 1930 Sanborn Co. insurance map (see insurance map #3) indicates that several large-scale changes occurred in the late 1920's. A 1925 fifty-five horsepower Ingersoll-Rand Type 20 diesel engine-ammonia compressor combination (photo DE-4-6), supplied by the Henry Vogt Co., replaced the older refrigerating machinery. [21] The large ice-storage houses (see insurance maps #1 and #2) were removed and replaced by a cold storage area attached to the main plant (see insurance map #3). The daily capacity was increased to fifteen tons of ice. It seems the rail siding was removed during this period, perhaps indicating a new source of ice for the railroad or a shift on the part of Verney to other markets (e.g. home or retail refrigeration), or both.

In 1946, Harry E. Mayhew assumed control and retained it until his death in 1973. [22] Mayhew added gasoline, lubricating oil, heating oils and burner service to the product line. After Mayhew's death, the Downing Fuel Service Co. ran the plant for a few years. Its daily production was limited to about five tons, sold primarily to the Paramount Poultry Company of Herbeson, Delaware, for use in refrigerated trucks. By 1976 ownership had passed to Mr. Sudler Lofland, who began to scrap the ice-making machinery.

III. Process Description

Virtually all mechanical refrigeration relies upon two basic principles of thermodynamics.

1) In order for a liquid to change state to a vapor, a certain quantity of heat (the actual amount depends upon the particular liquid) is required, the "latent heat of vaporization." Conversely, for this vapor to condense back to a liquid, it must give up the same quantity of heat, the "latent heat of condensation."

2) A liquid, under sufficiently low pressure, will vaporize, taking up its latent heat of vaporization from its surroundings. Conversely, a vapor, subjected to sufficiently high pressure, will condense, giving off its latent heat of condensation.

In the latter half of the 19th century, two systems of mechanical refrigeration were successfully developed, classified according to the type of refrigerant used. The earliest, known as "cold air" machines, utilized air as a refrigerant. Air, at atmospheric pressure, was mechanically compressed in a cylinder. This compression created heat, which was removed through a water bath surrounding the cylinder casing. After adequate cooling, the air was allowed to expand rapidly, taking heat from its surroundings and thus producing refrigeration. [23]

"Destined to become vastly more important than cold air machines were those which used liquids capable of being alternately vaporized and liquified." [24] A number of rather volatile liquids were experimented with, but ammonia became the most significant and widely used refrigerant for several reasons. It is a gas at normal pressure and temperatured, and does not condense until well below the freezing point of water. It has a relatively high latent heat of vaporization, permitting large transfers of heat, using small quantities of refrigerant. This is particularly important because it allows machines using ammonia to be much smaller than those using other refrigerants. Finally, the pressures required for the use of ammonia as a refrigerant are comparatively low and easily obtainable. [25]

Two types of machines were developed, employing ammonia as a refrigerant -- the ammonia absorption type and the vapor compression type. Absorption machines were widely used during the 1870's, but, by 1885, the compression type was developed to the practical level. [26] The compression machine was by far the most important development in refrigeration machinery. Using various forms of Freon as a refrigerant, it is the basis of nearly all refrigeration applications today. [27] Milford Ice and Coal employed an ammonia compression system and its operation will be described in detail below.

The compression system had four major sections:
1) the refrigerator or evaporator, where liquid ammonia was vaporized, producing the refrigeration effect, 2) the compressor, which drew the vapor from the evaporator and compressed it into 3) the condensor, where the vapor cooled and liquified, and 4) the regulating valve, which controlled the flow of liquid ammonia into the evaporator. [28]

Milford Ice and Coal employed two vertical compressors (i.e., the compression piston ran vertically) which could be used separately or in tandem to increase production output. [29] One was supplied by the York Manufacturing Company of York, Pennsylvania (photo DE-4-8); the other, by the Frick Company of Waynesboro, Pennsylvania (photo DE-4-7). [30] Pressurized ammonia gas, from William B. Severn Inc. of Philadelphia was introduced into one or both compressors and compressed to about 150 lbs./in. The ammonia capacity of the system was approximately 1,500 lbs. [31]

The ammonia gas was forced, under pressure, into the condensors, a series of three 1-foot diameter pipes about 25 feet long, through which the ammonia was pumped. The ammonia gas was cooled by circulating water and condensed to a liquid, still at high pressure. Water for this operation constantly circulated through the larger pipes and around the smaller ones that contained the ammonia. The water was cooled outside the plant in an apparatus known as an Aquatower (photo DE-4-3, DE-4-4), which consisted of a large fan that cooled the water as it dripped down over a set of small metal fins. It was then pumped back into the condensor.

From the condensor, the now-liquid ammonia flowed through the expansion valve into a network of pipes that ran under a 25 x 25 x 5-foot galvanized-iron tank containing the cooling medium, brine. Here, due to the lower pressure within this piping, the ammonia liquid vaporized, taking heat from the brine. It was then drawn back into the low pressure side of the compressor at about 15 lbs./in.^{2}, where the cycle began again. [32]

The use of brine as a cooling medium proved more economical than a "direct-cooling" system because it was possible to cool the brine to the necessary temperature for ice-making, and then shut down the plant. This eliminated the need for a night machine attendant and allowed regular maintenance to be performed without production loss. [33] The brine was a mixture of calcium chloride, supplied by the Industrial Chemicals Division of the Allied Chemical Corp., Morristown, New York, and water. This solution could be cooled to temperatures of eleven to fifteen degrees (sufficiently low to freeze water) without freezing. [34] It was circulated around the tank, to hasten freezing, by a propellor-like screw, driven by a small electric motor.

Galvanized iron cans, measuring 1 x 2 feet at the top and tapering 4 feet to the bottom, were filled with fresh water from a well on the property, and lowered into the brine by an electric winch (photo DE-4-10). They were then covered by 2 x 4-foot wooden hatches.

In the past, clear ice was thought to be pure and thus desirable. If undistilled water was frozen in a can, because of the air and impurities it contained, it would freeze opaque. When clear ice was in demand, Milford Ice and Coal agitated the water with compressed air. An article from Ice and Refrigeration describes this procedure as used in a larger plant:

> "As soon as a row of five cans . . . are filled, one of the five-branched air pipes . . . is dropped into the cans and attached to the nearest main . . . When ice cake is about half frozen, the long branched pipes are pulled out and the shorter ones inserted, when the water in the ice cans is frozen to within about one and one half or two inches of closing in center, the air pipes are lifted out, the remaining water, containing all the impurities thrown out during the crystallization of the water, is sucked out by means of a hose . . . and from another hose, connected with cold water tank, the small opening in ice cans is filled with water flowing down by gravity from the tank. The covers are then replaced and the water soon freezes without air agitation and leaving no mark whatever in cake of ice, which is clear throughout as is a cake of distilled water ice." [35]

After about twenty-four hours, the water froze and the cans, weighing three hundred pounds, were removed. The operator first removed the wooden hatch. He then moved the electric winch to a position above the cans to be removed (two cans were removed together), and raised them out of the brine (photos DE-4-11, DE-4-12). The winch was secured to a movable iron I-beam running across one dimension of the tank. It could also move along the beam, allowing its placement anywhere within that grid. The entire I-beam-winch assembly was then pushed, by hand, to a 5 x 5 x 5-foot stone-lined tank containing fresh water. The cans were submerged in this tank in order to loosen the blocks of ice from the cans (photos DE-4-13, DE-4-14). They were then raised and pushed to a cradle-like apparatus that tilted to the horizontal (photo DE-4-15, DE-4-16, DE-4-17), allowing the ice blocks to slide through a small opening into the cold storage area (photo DE-4-18). The cans were tilted back, refilled with well water and replaced in the brine (photo DE-4-20).

The cold storage area was constructed of molded concrete block insulated with a layer of cork (photo De-4-19). The large area, approximately 25 x 25 x 25 feet (see insurance map #3), was closed off by 1975, as sales did not warrant its use. The ice produced in 1975, was kept in the smaller area and passageway directly behind the loading dock. These areas were cooled directly through piping connected to the main system. The ice was never kept in storage for more than a few hours. The daily production was sold at night to the poultry trucks.

Ice was sold by the block, bagged (cubes), crushed or blown (ground extremely fine and literally blown into the refrigerator trucks.) Three machines, built by the Cochrane Corporation of Philadelphia, altered the ice blocks to the desired form on the loading platform (photos DE-4-2, DE-4-21, DE-4-22, DE-4-23, DE-4-24, DE-4-25).

NOTES

[1]Anderson, Oscar, Refrigeration in America, (Princeton, 1953).

[2]Evans never proceeded past the drawing board, although his machine was theoretically sound. Perkins contrived and patented a machine while working in England in 1834. See Anderson, Refrigeration, pp. 71-85, for more detailed accounts of these and other people involved in refrigeration experimentation.

[3]Cummings, Richard, The American Ice Harvests, (Berkeley, 1949), p. 46; Fernald, Frederik A., "Ice Making and Machine Refrigeration," Popular Science Monthly 39(May 1891): 19.

[4]Woolrich, Willis R., "The History of Refrigeration: 220 Years of Mechanical and Chemical Cold: 1748-1968," American Society of Heating, Refrigeration and Air Conditioning Engineers Journal (July, 1969): 35.

[5]Anderson, Refrigeration, p. 86.

[6]Ibid., p. 87; U.S. Department of Commerce, Bureau of the Census, Abstract of the Census of Manufactures, (Washington, 1919).

[7]Anderson, Refrigeration, p. 106.

[8]Ibid., p. 96.

[9]Ibid., p. 109. The increase in consumption reflected growing numbers of Americans purchasing home refrigerating equipment for the preservation of food. In 1914, over 21,000,000 tons of manufactured ice alone were consumed, more than four times the estimated natural ice consumption in 1880.

[10]U.S. Department of Commerce, Bureau of the Census, Biennial Census of Manufactures: 1931, (Washington, 1935), p. 147.

[11]U.S. Department of Commerce, Bureau of the Census, Census of Manufactures: 1967, vol. 2, pt. 1, (Washington, 1971), pp. 201-5.

[12]Twelfth Census of the United States, 1900: Manufactures, 9:677; Fourteenth Census of the United States, 1920: Manufactures, 10:963, 965; cited by Cummings, Ice Harvests, Appendix F.

[13]Anderson, Refrigeration, p. 40.

[14]For a discussion on the development of refrigerated transport of produce and meat, see Anderson, Refrigeration, pp. 142-188, 224-231, 244-272.

[15]Abstract: 1914, P. 639.

[16]Drury, Horace B., Production and Capacity Control in the Ice Industry Under the NRA, Office of National Recovery Administration, Division of Review, 1936, p. 15.

[17]Delaware State Chamber of Commerce, Directory of Manufactures: State of Delaware, (Wilmington, 1960). Six of these plants are owned by one firm, the Atlantic Ice Manufacturing Company.

[18]HAER interview with Robert Tucker, 8 August 1975. Although no production figures were available in 1960, every plant in Delaware was listed in the Directory of Manufactures as having less than five employees.

[19]Unless otherwise noted, all information concerning the history of Milford Ice and Coal is from the Milford Chronicle, Ninetieth Anniversary Edition, October 1968, p. F-7.

[20]Sanborn Co., Insurance Map #1, Milford, Delaware, 1904 (enclosed); Interview with Robert Tucker, 1975.

[21]Author's inspection of plant, 8 August 1975; Sanborn Co., Insurance Map #3, 1930.

[22]HAER telephone interview with N.B. Downing, 14 August 1975.

[24]Ibid., p. 78.

[25]Claypool, J.B. and W. Jones, "Investigation of an Ammonia Compression Refrigerating System to Determine the Effect on Refrigeration by Varying the Head Pressure, All Other Quantities Remaining Constant," (B.S. thesis, University of Pennsylvania, 1913), p. 1; Anderson, Refrigeration, p. 84.

[26]Anderson, Refrigeration, p. 87; Greene, Arthur M., The Elements of Refrigeration, (New York, 1919), p. 6. In absorption type, no compressor is required. The pressure that controls vaporization and liquification is produced by the interaction of ammonia and water. At low temperatures, water has a great affinity for ammonia, while they tend to separate when heated. A solution of aqueous ammonia is heated in a vessel known as a generator, driving off anhydrous ammonia vapor at high pressure. The vapor passes into a condensor, where the heat is carried away by circulating cold water or air, and the vapor is condensed. From the condensor, the liquid, anhydrous ammonia, is admitted to an evaporator where, due to lower pressure, it vaporizes rapidly, drawing heat from a cooling medium such as brine. The vapor then goes to an absorber where the temperature is lowered and the

ammonia and water reunited in solution.

Another type of machine based on the absorption principle utilized sulfur dioxide's affinity for water. A pump created the initial low pressure required for evaporation of the water and helped the sulfur dioxide to maintain it. The lower pressure caused a portion of the water to evaporate (the sulfur dioxide absorbed this water vapor), taking heat from and freezing the main body.

[27]Anderson, Refrigeration, p. 87; Ewing, J.A., The Mechanical Production of Cold, (Cambridge, 1908), p. 59. The compression machine is the most efficient, explaining its wide commercial development.

[28]Selfe, Norman, Machinery for Refrigeration, (Chicago, 1900), p. 56.

[29]The vertical compressor lasts longer than its horizontal counterpart because the bottom cylinder wall of the horizontal type wears due to gravity acting on the piston.

[30]Author's inspection of plant, 8 August 1975. Unless otherwise noted, all other specifics relating to the plant's process are from this inspection.

[31]Interview, Robert Tucker.

[32]Ibid.

[33]Anderson, Refrigeration, p. 100.

[34]interview, Robert Tucker.

[35]"A Modern All Raw Water Can Ice Making Plant," Ice and Refrigeration 43 (1 October 1912): 118.

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